Man and Machine: Assessing the Efficacy of Athlete Monitoring Tools in Highly Trained Swimmers

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by

Stephen Crowcroft

Bachelor of Human Movement (Honours)

Faculty of Health, Sport and Exercise Discipline

University of Technology Sydney,

Australia

CERTIFICATE OF AUTHORSHIP AND ORIGINALITY OF THESIS

I certify that the work contained in this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Health, Sport and Exercise Discipline at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis. This document has not been submitted for qualifications at any other academic institution.

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Early into my time as a PhD student an Uber driver told me…

"Man will always beat machine" as he referred to a GPS monitor.

….. after that statement he quickly corrected himself and said… "The right man"

I thought about it for a long time.

Five years later, I think I have some data to support that (with context of course).

PREFACE

This thesis for the degree of Doctor of Philosophy is in the format of thesis by compilation and abides by the 'Procedures for Presentation and Submission of Theses for Higher Degrees – University of Technology, Sydney; Policies and Directions of the University'.

From the research design and data collection by the candidate, four manuscripts have been submitted to peer reviewed journals for publication. These papers are initially brought together by an Introduction. This provides a background, research problem, the purpose and significance of each of the studies. A literature review follows which provides an overview of athlete monitoring tools and coach decision-making. The manuscripts are then presented in a logical sequence following the development of research ideas within this thesis. Each manuscript has a similar structure of introduction, methodology, results, discussion, practical applications and conclusion. Figures, Tables and reference numbers have been retained. The summary chapter integrates all studies research ideas, concludes each study and provides direction for future research.

LIST OF ARTICLES SUBMITTED FOR PUBLICATION

Refereed Journal Publications

1. **Crowcroft, S.,** McCleave, E., Slattery, K., & Coutts, A. J. (2017). Assessing the measurement sensitivity and diagnostic characteristics of athlete-monitoring tools in national swimmers. *International Journal of Sports Physiology and Performance*, *12* (Suppl. 2), S2-95.
2. **Crowcroft, S.,** Slattery, K., McCleave, E. & Coutts, A. J. (Under review). Can a multi-factorial athlete monitoring system identify performance changes in swimmers? *International Journal of Sports Physiology and Performance*.
3. **Crowcroft, S.,** Slattery, K., McCleave, E. & Coutts, A. J. (Under review). Man vs. Monitoring: Assessing a coach's expectations of athletic performance, training intensity, perceived fatigue and recovery. *International Journal of Sports Physiology and Performance*.
4. **Crowcroft, S.,** Slattery, K., McCleave, E. & Coutts, A. J. (Under review). Do athlete monitoring tools improve a coach's understanding of performance change? *International Journal of Sports Physiology and Performance*.

Conference Proceedings & Abstracts

1. **Crowcroft, S.,** Slattery, K., McCleave, E. & Coutts, A. J. (2016) Assessing the signal-to-noise ratio of common athlete monitoring tools in national swimmers. *Presentation at Aspire Training Load Conference, Doha, Qatar.*
2. **Crowcroft, S.,** Slattery, K., McCleave. E. & Coutts, A J. (2017) Implementation of a multi-dimensional monitoring system to identify performance decrements in highly trained swimmers. *Presentation at European College of Sport Sciences (ECSS) Conference, Essen, Germany.*
3. **Crowcroft, S.,** Slattery, K., McCleave. E. & Coutts, A. J. (2018) Integrating coach and sport science: a multi-dimensional monitoring system to identify performance change in highly trained swimmers. *Presentation at Exercise and Sport Science Australia- Research to Practice conference, Brisbane, Australia.*

ABSTRACT

High performance sporting programs make substantial investments to develop and implement athlete monitoring systems to assist coaches understand how their athletes are responding to training. Despite the extensive reviews supporting the usefulness of athlete monitoring systems, it is still unknown if these systems contribute to a coaches' subjective assessment of how an athlete will perform. Therefore, the overall aim of this thesis was to assess the efficacy of an athlete monitoring system and a coach subjective assessment to identify performance changes and athlete training responses in nationally competitive swimmers. To achieve this, a series of four studies were conducted. Study 1 determined the signal-to-noise ratio and diagnostic accuracy of athlete monitoring tools to identify both improvements and decrements in performance. These findings showed clear week-to-week fluctuations of numerous monitoring tools that represented an athlete's acute changes in fitness and fatigue. However, this study also highlighted the poor diagnostic accuracy of athlete monitoring tools to identify performance change. Therefore, Study 2 examined the efficacy of a multi-factorial monitoring system to assess both short-term or longitudinal changes in performance. These findings identified an improved accuracy of a multi-factorial monitoring approach to assess longitudinal performance changes. However, the weaker diagnostic accuracy assessing short-term performance changes limits the practicality of this approach to assess an athlete's readiness to perform in training or competition. Study 3 aimed to compare a coach's expected perceived fatigue, recovery, training intensity and performance outcomes to actual athlete measures in well-trained swimmers. These findings showed a very strong association of coach predicted to actual athlete race results. However, there was a consistent discrepancy of coach expected to athlete reported training intensity and responses to subjective questionnaires. Finally, Study 4 assessed if the use of athlete monitoring tools could improve on a coach's prediction to identify performance changes. The findings from this study demonstrated the high diagnostic accuracy of a coach's subjective assessment of their athlete's performance. Although, no monitoring tools improved on a coach's

subjective assessment of performance. Collectively, this thesis provides initial support of the high accuracy of a swim coach's subjective assessment of their athlete's performances. However, the use of athlete monitoring tools may assist a coach to have a more comprehensive understanding of their athlete's responses to training.

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LIST OF ABBREVIATIONS

ASCTA	Australian Swim Coaches Teaching Association
AUC	Area under the curve
CI	Confidence interval
CL	Confidence limits
CDM	Classical decision-making
CMJ	Counter movement jump
CV%	Co-efficient of variation as a percentage
Exp.(B)	Exponential of unstandardised beta co-efficient
$Fatigue_{7d}$	The 7-day rolling average of perceived fatigue
FINA	Fédération Internationale de Natation
GEE	Generalised estimating equation
HR	Heart Rate
HRR	Heart rate recovery
HRV	Heart rate variability
KM	Kilometres
Ln rMSSD	The log transformed root mean squared sum of the consecutive R-R intervals
Ln $rMSSD_{7d}$	The 7-day rolling average of the log transformed root mean squared sum of the consecutive R-R intervals
LnRMSSD:RR	The ratio of the log transformed root mean squared sum of the consecutive R-R intervals to R-R interval
$LnRMSSD:RR_{7d}$	The 7-day rolling average of the ratio of the log transformed root mean squared sum of the consecutive R-R intervals to R-R interval
NDM	Naturalistic decision-making
POMS	Profile of mood state
QIC	Quasi Likelihood under Independence Model Criterion
ROC	Receiver operating characteristics
S.E.	Standard error
SD	Standard deviation
SMC	Smallest meaningful change
sRPE	Session rating of perceived exertion
TE	Technical error
TL	Training load
TQR	Total quality recovery
TQR_{7d}	The 7-day rolling average of both total quality recovery
Wellness%	Total wellness score and expressed as a percentage of highest possible total
$Wellness\%_{7d}$	The 7-day rolling average of total wellness score and expressed as a percentage of highest possible total
β	Unstandardised beta co-efficient